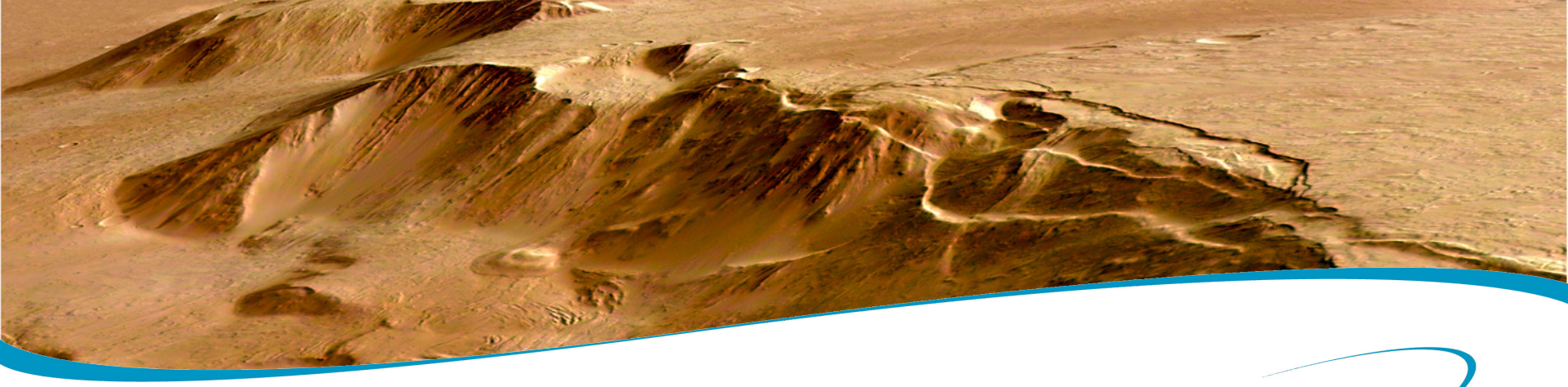


ThalesAlenia Space
A Thales / Finmeccanica Company

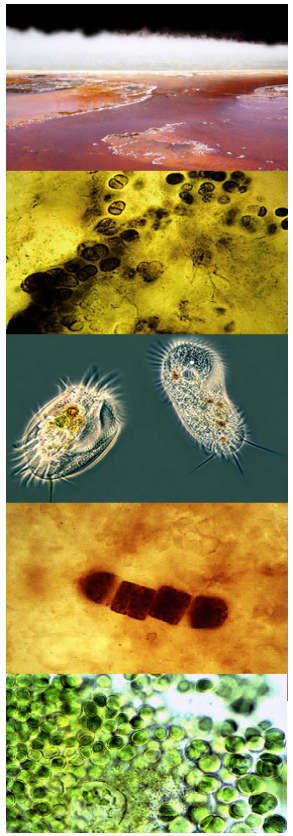
EXOMARS Mission Description and Architecture

Vincenzo Giorgio
Thales Alenia Space- Italia (Turin)
Bordeaux, June 26th 2007

THALES

Business Unit Optical Observation and Science

First European led Exploration Mission, combining development of exploration enabling technology with major scientific investigations



❑ Main technology objectives

- ➢ Safe Entry, Descent and Landing of a large size payload
- ➢ Surface mobility (Rover) and access to the subsurface (Drill)
- ➢ Forward Planetary Protection

❑ Main scientific objectives

- ➢ Search for traces of past and present life
- ➢ Characterise Martian geochemistry and water distribution
- ➢ Improve the knowledge on Martian's environment and geophysics
- ➢ Identify surface hazards to future human missions

The Exomars Phase B, run by Thales Alenia Space - Italia (formerly Alcatel Alenia Space – Italia), has studied three different scenarios for the ExoMars mission:

- **Baseline**
- **Option 1**
- **Option 2**

Mission - Baseline

- **Baseline Mission: single SOYUZ launch in 2013**
  - **Valid also for Option 1**

- **Composite** Carrier Module (CM) plus 1000 kg Descent Module Composite (DMC) including the Rover.
  Data relay function to be provided by NASA via MRO

- **Launch** Late July 2013, from Kourou on Soyuz ST 2-1b/Fregat.
  Mission and spacecraft design to be compatible with 2015 launch

- **Arrival** Jan 2016 (Dec 2017) through a delayed T4 trajectory, outside the dust storm season

- **Landing** Direct entry from hyperbolic trajectory and landing at:
  - Latitudes between 15° S and 30° N
  - All longitudes
  - Altitude ≤ 0 km, relative to the MOLA zero level

Mission - Option 1

Option 1 Mission: Baseline Mission + Orbiter by Soyuz launcher

- **Orbiter** — Small telecommunication Orbiter providing the link between Earth and the Rover and Earth and the "reduced" GEP
- **Launch** — Nov. 2012, from Kourou on Soyuz 2-1b. Mission and Spacecraft design to be compatible with 2013 launch
- **Arrival** — Oct 2014, more than 1 year before the Carrier mission

Mission - Option 2

❑ Option 2 Mission: Orbiter + DM Composite with Ariane 5 launcher

- **Composite** Orbiter Module (OM) plus enhanced 1200 kg Descent Module Composite (DMC) including Rover.
  Data relay function to be provided by Orbiter
- **Launch** Sep 2013, from Kourou by Arian 5 ECA. Mission and Spacecraft design to be compatible with 2015 launch
- **Arrival** Jan 2016 (Jan 2018) through a delayed T4 trajectory, outside the dust storm season
- **Landing** Entry from Mars elliptic orbit and landing at:
  - Latitudes between 15º S and 30º N
  - all longitudes
  - Altitude ≤ 0 km, relative to the MOLA zero level

➢ ***Option 2 resulted to be unfeasible after AR5 performance analysis***

- Phase B1 completed in March this year with the System Requirements Review (SRR)
- SRR Board held in April
- Programmatic and financial proposal for the Implementation phase, B2-C/D-E) delivered to the Agency by end of April
- Implementation Review completed by the Agency on 11th June

IREV objectives:

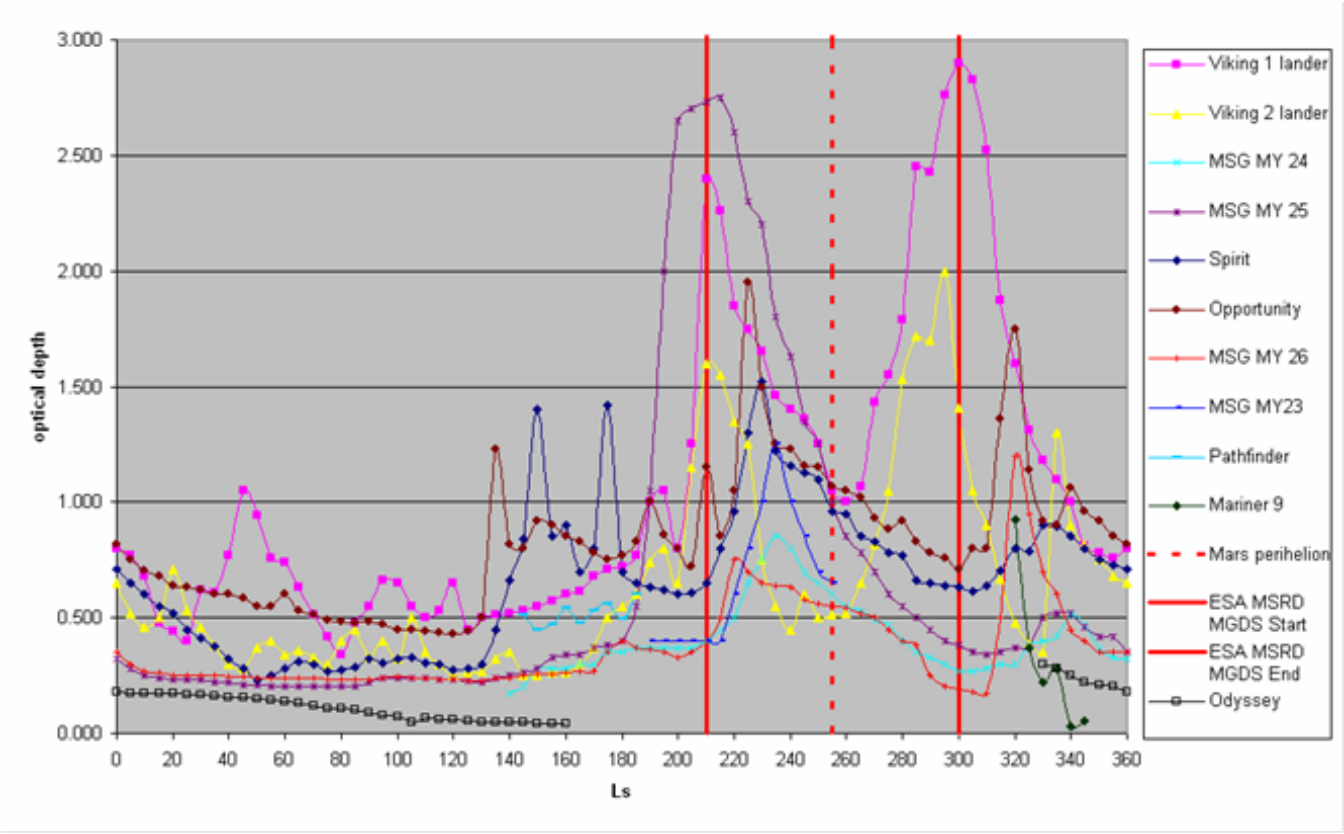
- Mission configuration
- Final payload configuration
- Launch date.

Post SRR Inputs

- Ariane 5 performance
- Global Dust Storm
- Payload complement

- AR 5 performance ~ 5300 Kg (20% less than at beginning of phase B1)

- The graph shows that From Ls = 340 deg to about 180 deg a clean environment (low probability that τ >1) is met.



- A valuable set of Pasteur instruments would have to weigh approximately 16.5 Kg.
- Rover mass is actually evaluated to be 205 Kg, from previous 165 Kg
- 30 Kg would be needed for the GEP instruments and the relevant services
  - Accommodation constraints indicate in the vented airbags solution the most feasible one.

IRev Conclusion

- In accordance with its objectives and SRR outcomes the Implementation Review has selected:
  - The Enhanced Baseline Mission
  - Compatibility with both Ariane 5 and Proton
  - The Airbag Vented Configuration

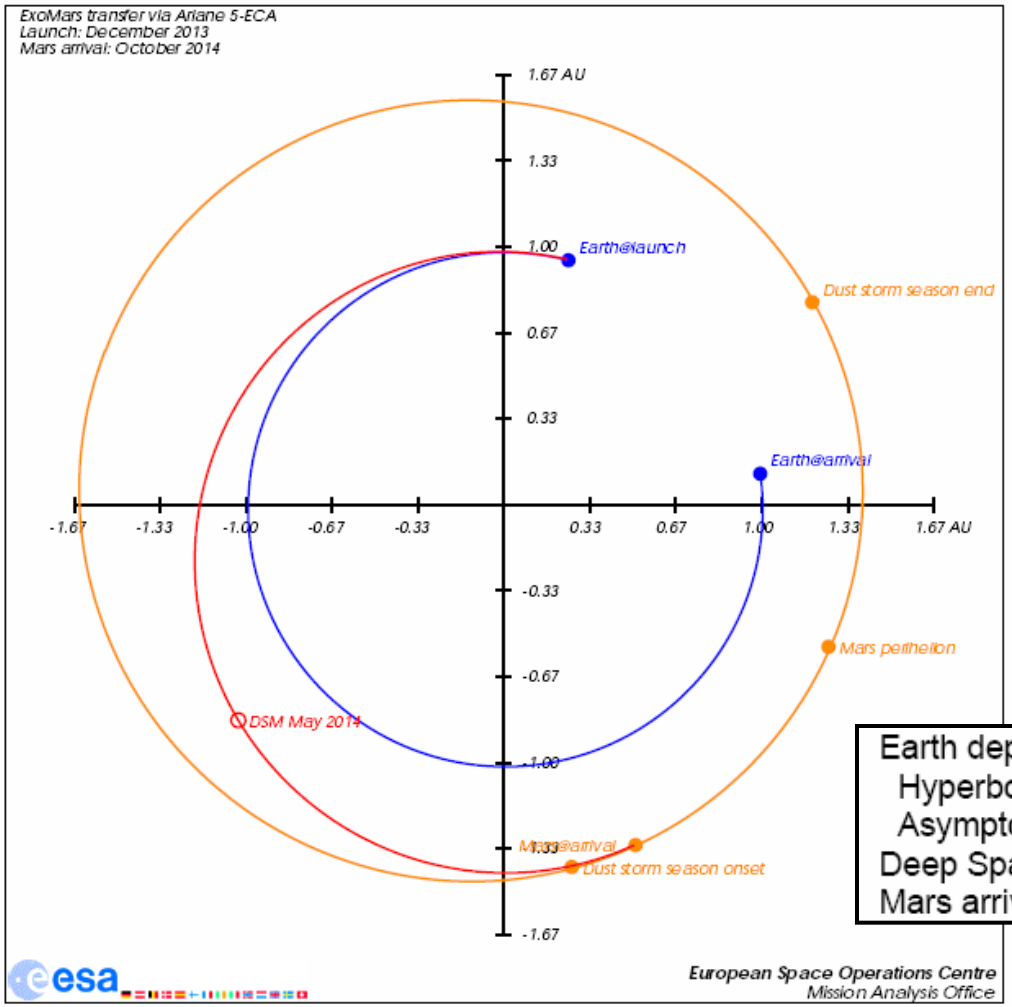
- All Rover operations are planned and executed from the Rover Operations Control Centre (ROCC) located in Torino (Italy)
- During the Cruise Phase the Spacecraft Composite operations are controlled by the ESA Deep Space antennas and Mission control centre located in ESOC, Darmstad Germany.

- **Enhanced BASELINE with Ariane 5 launcher**
  - **Allows 16.5 kg of PPL and the GEP**
  - **Is compatible with PROTON**

- **Composite** Carrier Module (CM) plus 1200 kg Descent Module Composite (DMC) including Rover.
  Data relay function provided by NASA via a NRO (NASA Relay Orbiter) MRO, and any future NASA Mars orbiting spacecraft

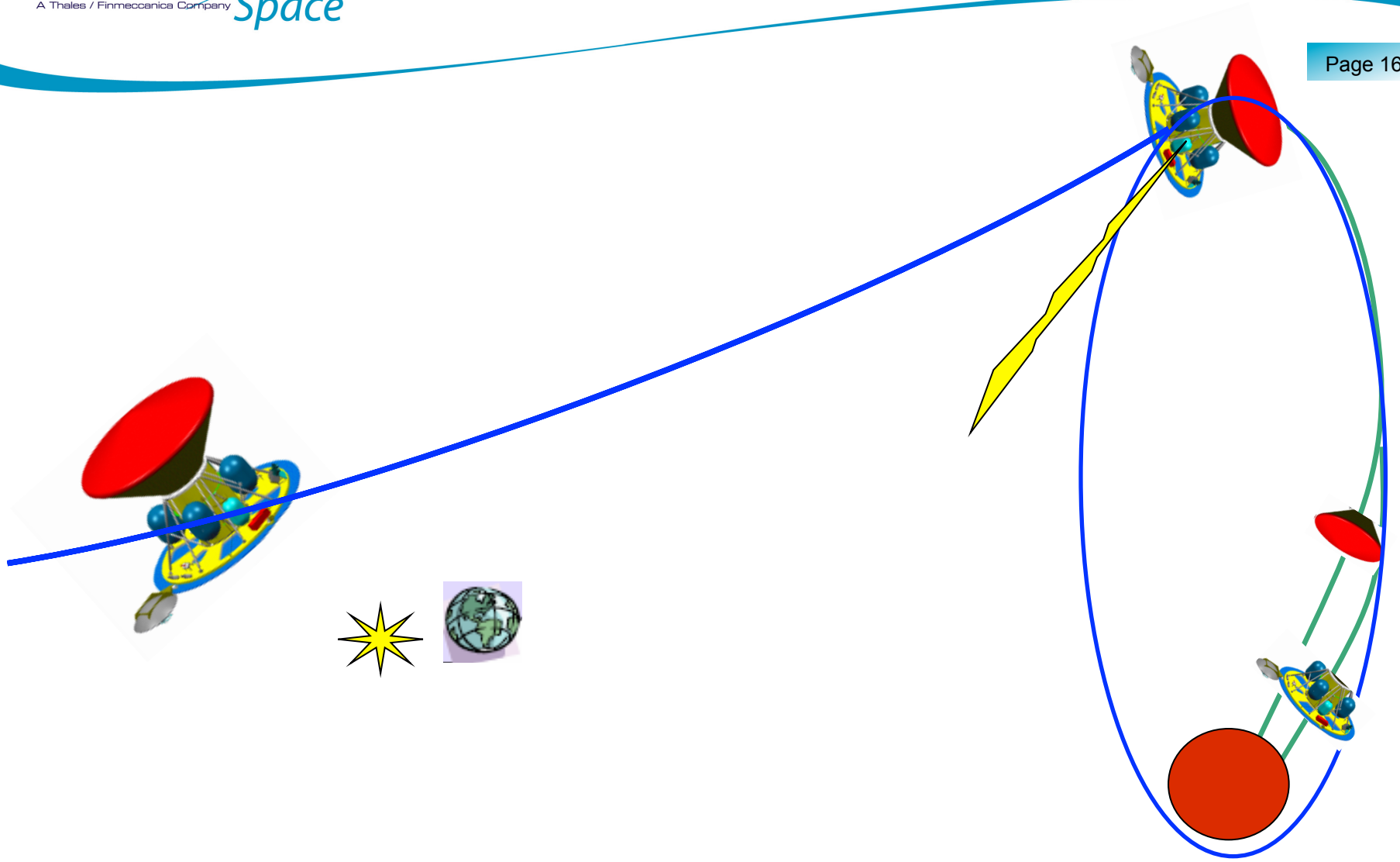
- **Launch** — Nov 2013, from Kourou on Ariane 5. Mission and spacecraft design to be compatible with 2015 launch
- **Arrival** — Sep. 2014 through a T2 transfer trajectory, during the dust storm season.
  Wait till May 2015 in Mars Orbit
- **Landing** — From elliptic orbit around Mars and landing at:
  - Latitudes between 10º S and 30º N
  - all longitudes
  - Altitude ≤ 0 km, relative to the MOLA zero level

Mission – AR 5 Enhanced baseline



Earth departure date	2013, Nov 29 - Dec 19
Hyperbolic excess velocity [km/s]	2.365 to 2.449
Asymptote eq. declination [°]	0.0
Deep Space Manoeuvre [m/s]	915 to 973
Mars arrival date	2014, Oct 03 - Oct 05

Enhanced Baseline Release from Orbit



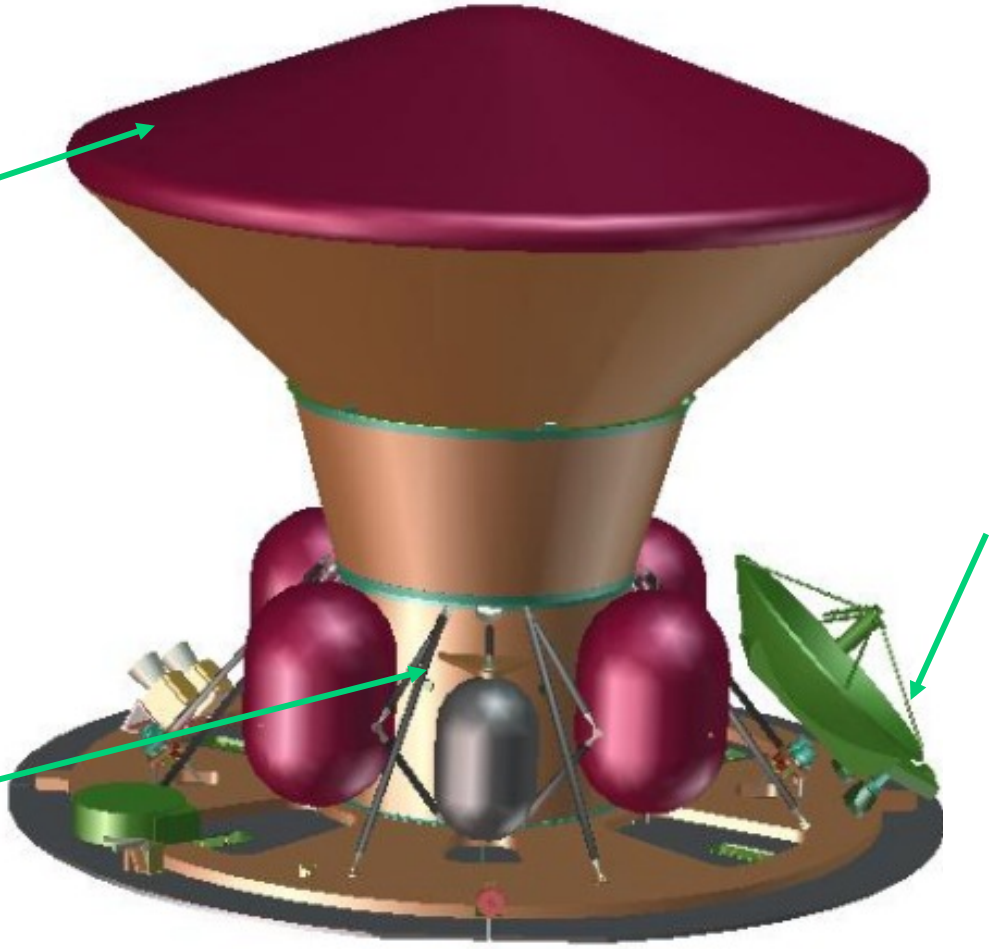
Enhanced Baseline Benefits

- Quick (< 1 year) journey to Mars
- Free selection of landing epoch
- Enhanced landing site accuracy, due to DM deployment from Mars orbit
- Larger DM and payload than in the Soyuz scenarios
  - The above described mission can also be launched by Proton from Baikonur

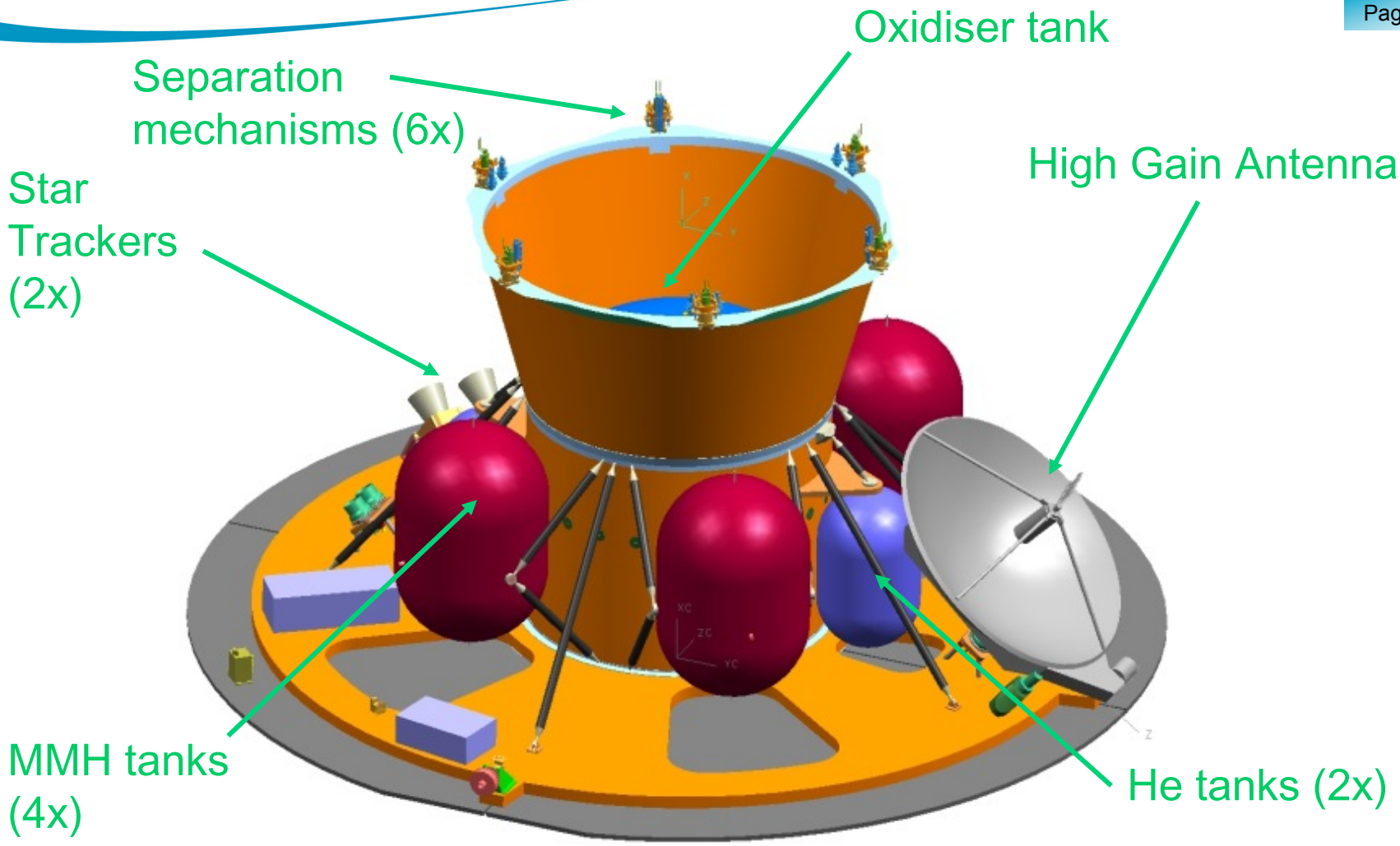
Max. theoretically allowed mass:

- DM mass = 1350 Kg
- Carrier mass = 750 Kg
- Propellant load = 2700 Kg

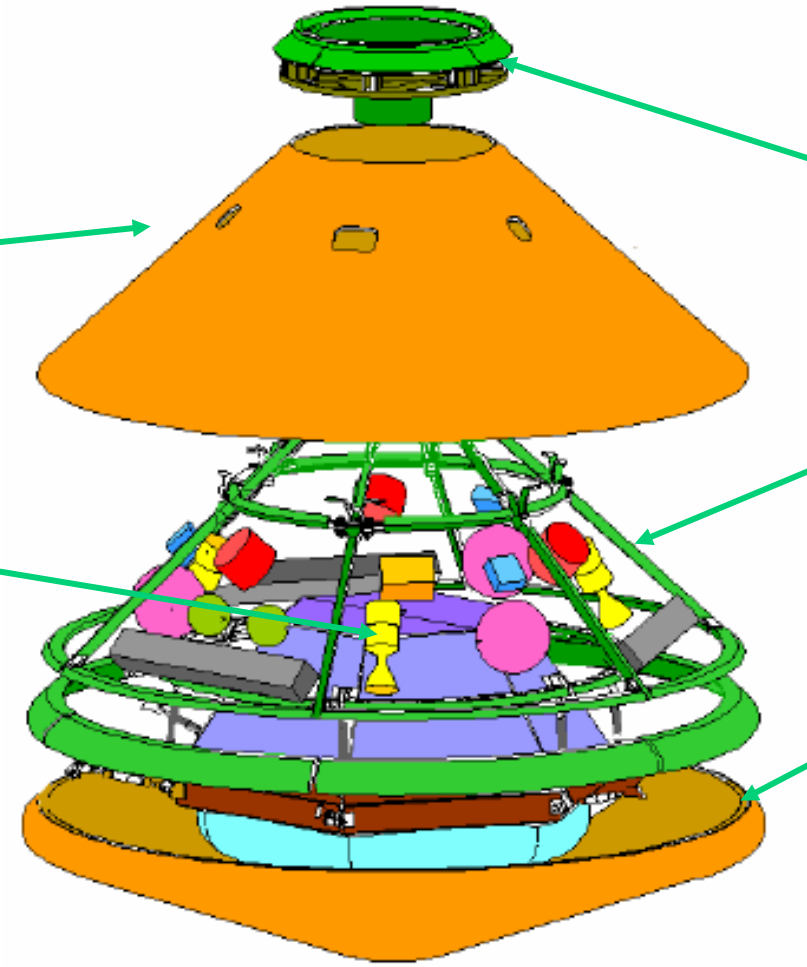
Descent Module
(Rover inside)



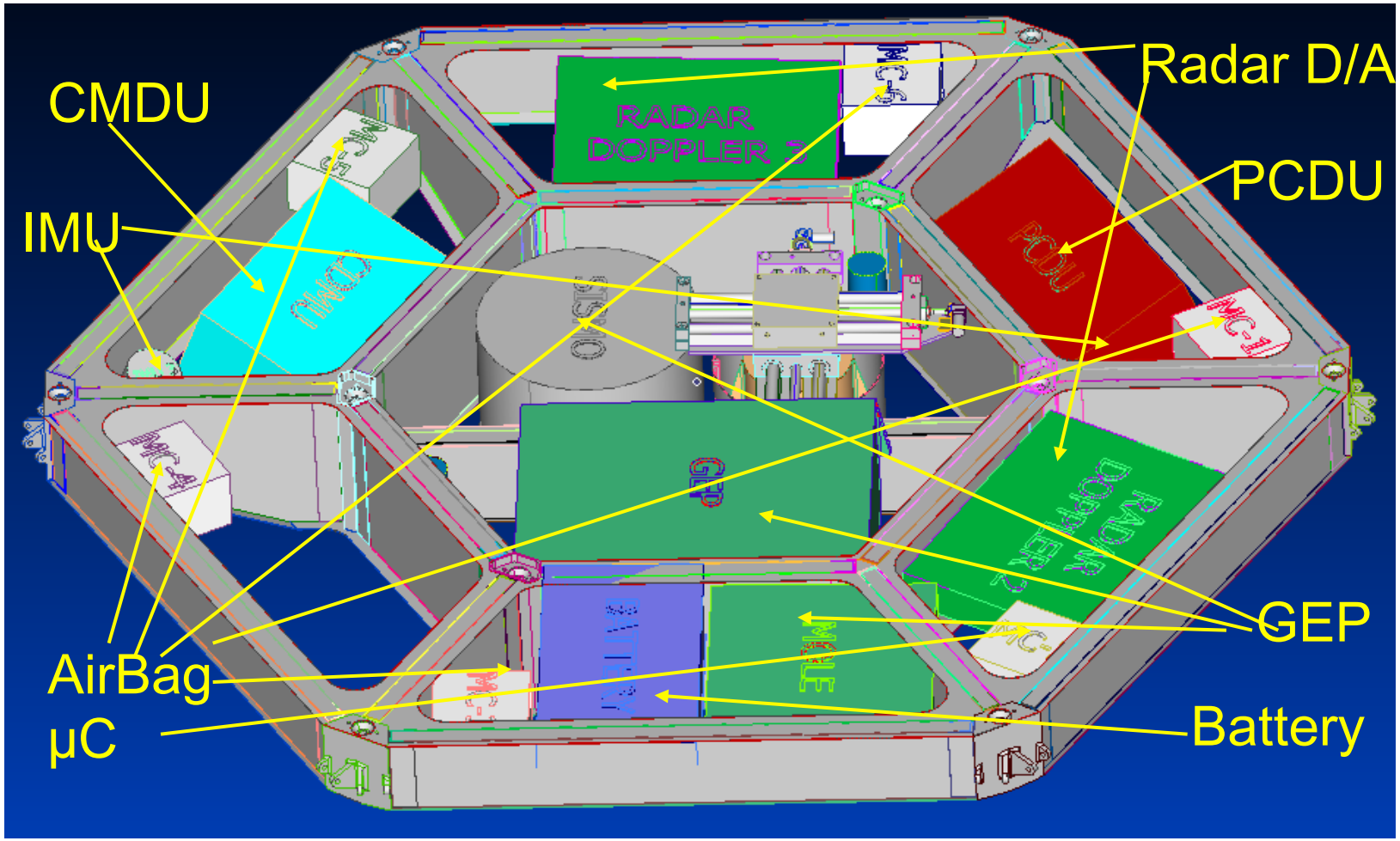
Carrier Module



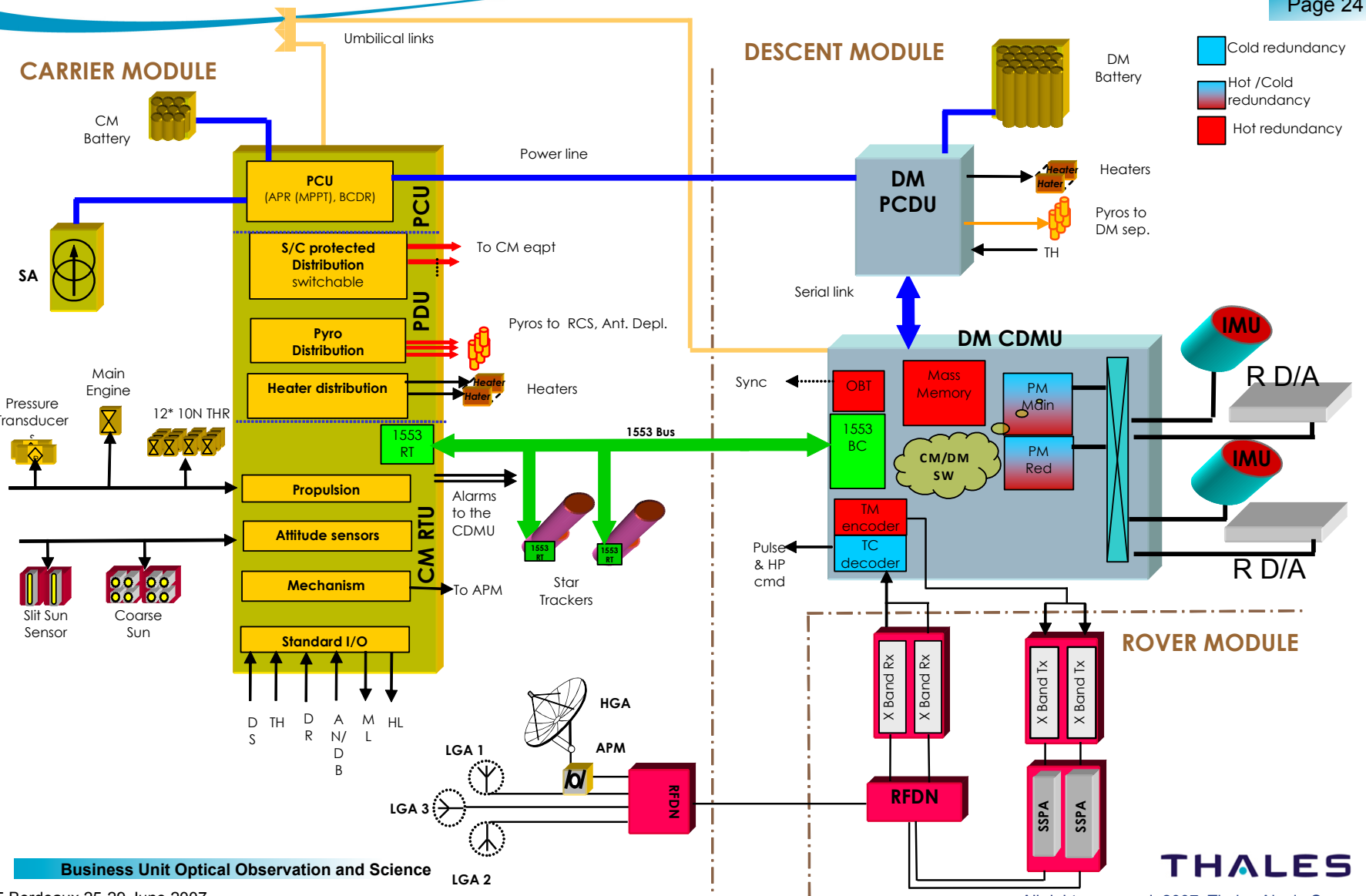
Descent Module Configuration

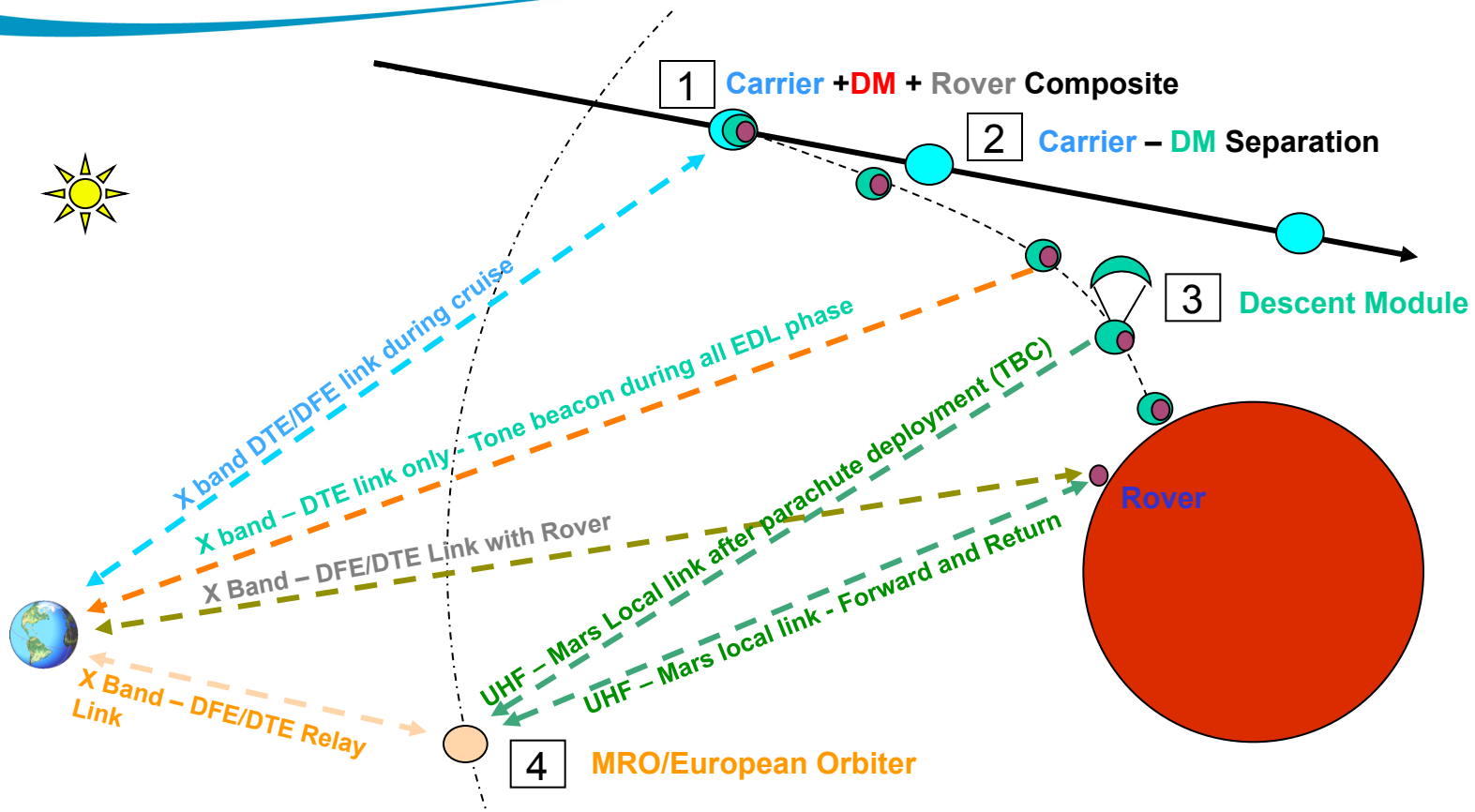


- Lander current mass ~ 550 Kg
- Limit of the current airbags design ~ 600 Kg
  - Importance of the running test phase



COMPOSITE AVIONICS WITH CARRIER





1 Launch to Cruise | 2 Separation | 3 Entry, Descent and Landing | 4 Mars Ground Operations

Vented ABS testing in CIRA (courtesy Aerosekur)

Descent Module Composite (DM + Rover) is PP Category IV b:

- Less than 30 bacterial spores (Viking post-sterilisation level) on surfaces for parts coming into contact with the scientific samples
- Microbiological controls
- Clean room assembly (with bioburden controls)
- Lander recontamination prevention (bio-shield)
- Organic material inventories.
  - Carrier will crash on Mars: sterilized by high temperatures reached during the atmospheric entry (MER approach) .

❑ Bridging B1

The phase B1 bridging is in progress, to study the enhanced B/L and proceed with breadboarding activities.

The Baseline Consolidation Review BCR) will be held before the end of the year.

The BCR will pave the way to the system PDR to be held in spring 2008.

- Carrier CDR, in December 2010 (first at module level) to authorize CM PFM Integration

- Rover and DM CDR in March and July 2011

- Composite CDR, in November 2011, to give the go-ahead for the Composite PFM AIT

- FAR in May 2012
- Long launch campaign (~ 6 months) due to RHU (2xRover, 1xLander)late integration:
  - Rover onto SES
  - SES into DM
  - Aseptic assembly
- Three weeks optimal launch window (29 Nov. - 19 Dec.2013)

Phase F Programmatics

- Arrival at Mars late September 2014
- Mars Orbit Insertion October 2014
- Orbiting (and observation?) until late April 2015
- Landing starting from early May 2015

Vented Airbag BB Test